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PRELIMINARY EVALUATION OF A REGIONAL SECONDARY UPGRADER AND SATELLITE MINING/ AOSTRA TACIUK PROCESS PRODUCTION FACILITIES

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TABLE OF CONTENTS

		Page
1.0	SUMMARY	1
2.0	INTRODUCTION	2
3.0	ATP CASE	3
4.0	REGIONAL SECONDARY UPGRADER	4
5.0	SATELLITE MINING/ATP PRODUCTION FACILITIES	7
6.0	PIPELINES	11

APPENDICES

A	ADVANCEMENTS IN DEVELOPMENT OF THE AOSTRA TACIUK PROCESSOR	
B	TOMORROW'S TECHNOLOGY TODAY - THE AOSTRA TACIUK PROCESS	

1.0 SUMMARY

This study was undertaken to evaluate the application of the AOSTRA Taciuk Process (ATP) to the concept of regional upgrader.

Consistent with the design basis detailed in the Alberta Chamber of Resources report entitled "Regional Upgrader and Satellite Production Facilities - Preliminary Evaluation" (ACR Report) for the base (Base) case, an alternate case employing satellite mining/ATP production facilities and regional secondary upgrader was developed and evaluated. (ATP Case).

The results of economic analysis have indicated that the ATP case has a significant economic advantage in terms of the supply cost per barrel of synthetic crude oil (SCO) over the Base case. The advantage is in the order of $5 per barrel of SCO.

2.0 INTRODUCTION

2.1 Background

During the second half of 1987, ACR evaluated the concept of regional upgrader. The results of this evaluation were presented in the ACR Report.

The Base case in the ACR report was developed for production of 30,000 BPCD of bitumen. The upgrader design was based on the VEBA Combi-Cracking technology and was located approximately 30-50 km northeast of Edmonton. The upgrader produced 31,200 BPCD of a fully upgraded SCO suitable for the Canadian refinery market. The feed for the upgrader was bitumen and was obtained from two 15,000 BPCD satellite mining/hot water extraction production facilities located in Fort McMurray. Diluent recycle was used to assist in pipeline transport of bitumen. Also evaluated by ACR at that time were three other cases that explored the effects of size, location, and degree of integration.

Economics of all cases were evaluated based on the determination of the supply cost per barrel of SCO. This was defined as the price (revenue) per barrel necessary to meet all upstream costs over the life of the project discounted at a social rate of return of 10%, assuming no taxes, royalties, inflation, or depreciation.

2.2 Study Objectives

In order to evaluate the application of the ATP to the concept of regional upgrader, AOSTRA undertook an inhouse study entitled "Preliminary Evaluation of a Regional Secondary Upgrader and Satellite Mining/AOSTRA Taciuk Process Production Facilities".

The ATP is a thermal retorting process developed by AOSTRA which provides for simultaneous extraction and primary upgrading of bitumen derived from mined oil sands. The ATP produces cracked distillates that are similar to fluid coking distillates in terms of yield distribution and quality. Details on the ATP have been included in Appendices A and B.

The evaluation of the ATP is based on the premise that the ATP distillates are suitable for hydrotreating directly in a regional secondary upgrader to SCO.

Consistent with the design basis for the Base case, detailed in the ACR report, the ATP case employing satellite mining/ATP production facilities, and a regional secondary upgrader was developed and evaluated.

This report outlines the methodology used in developing and evaluating the ATP case and summarizes the results.

3.0 ATP CASE

3.1 Case Description

The secondary upgrader employing the hydrotreaters and support units is located approximately 30-50 km north east of Edmonton. The feed for the secondary upgrader is the ATP distillates and is obtained from two 15,107 BPCD satellite mining/ATP production facilities. The satellite facilities are located in the Fort McMurray region 50 km from a main trunk pipeline. The trunk line extends approximately 440 km to the Edmonton area with a SCO line to Edmonton from secondary upgrader. The secondary upgrader, as in the Base case, produces 31,200 BPCD of fully upgraded SCO suitable for the Canadian refinery market.

The ATP case is illustrated in Figure 3.1.

3.2 Economic Analysis

The economics of the ATP case were also, as in the Base case, evaluated based on the determination of the supply cost to produce a barrel of SCO. The supply costs were expressed per barrel of SCO to put all costs for all cases on a consistent basis.

The supply cost per barrel of SC0 for the ATP case is $28.20 versus $33.33 for the Base case. Table 3.1 shows the breakdown of these costs among the various components for each of the cases.

For the ATP case the detailed capital and operating costs upon which the supply costs are based are contained in the individual sections of this report along with descriptions of the scope. All estimates, as in the Base case, were prepared in 1987 3Q Canadian dollars. It is AOSTRA's opinion that the accuracy of the estimates are within ±25%.

FIGURE 3.1

ATP CASE BLOCK FLOW DIAGRAM

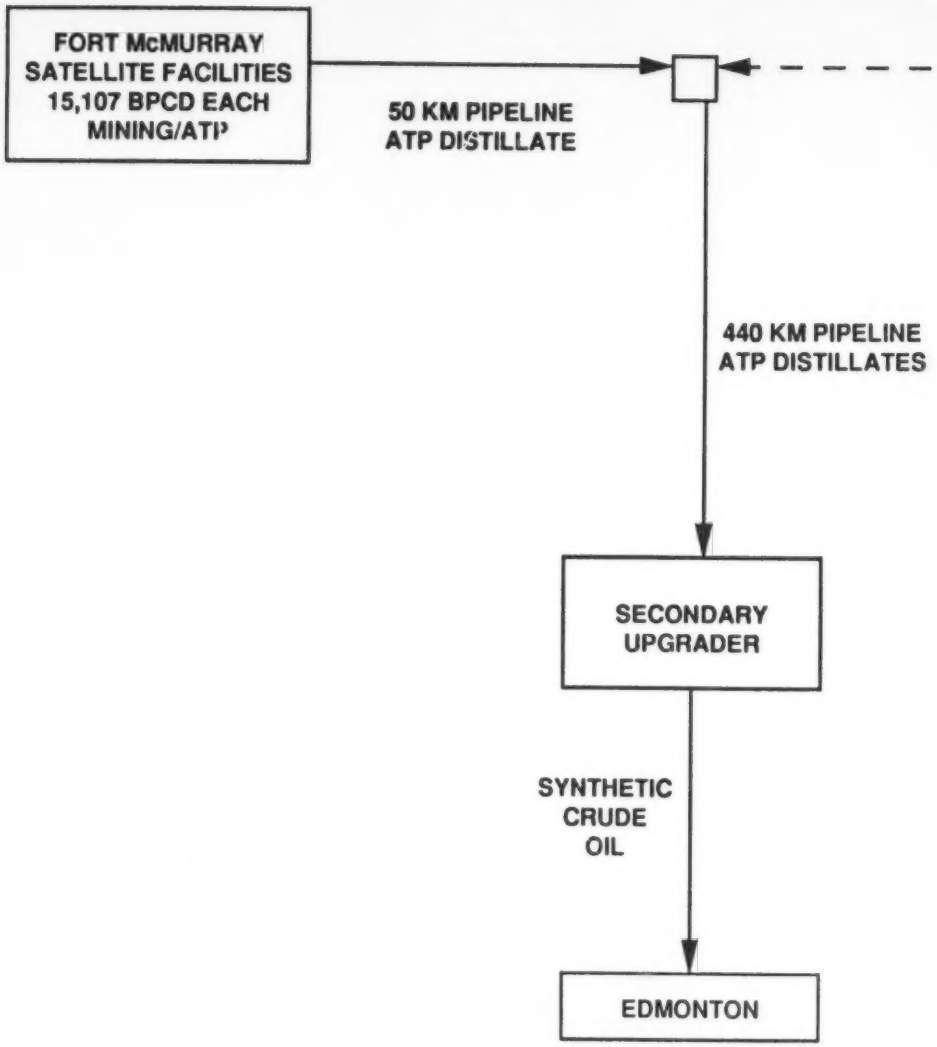


TABLE 3.1

SUMMARY OF COST ESTIMATES AND ECONOMIC ANALYSIS - 1987 CAN. $

	CASE	
	ATP	BASE
UPGRADER		
Capacity		
SCO,BPCD	31,200	31,200
ATP Distillates,BPCD	30,213	
Bitumen,BPCD		30,000
Capital,$MM	467.2	683.7
Operating,$MM/Yr	51.3	69.7
Sulfur Revenue,$MM/Yr	7.0	10.6
Cost of Service,$/Bbl of SCO	9.3	13.0
SATELLITE FACILITIES (EACH)		
Capacity		
ATP Distillates,BPCD	15,107	
Bitumen,BPCD		15,000
Capital,$MM	272.3	291.5
Sustaining Capital,$MM	56.7	159.3
Operating,$MM/Yr	59.5	58.0
Cost of Service,$/Bbl of SCO	17.5	17.9
TRUNK PIPELINE		
Capacity		
ATP Distillates,BPCD	30,213	
Bitumen,BPCD		30,000
Capital,$MM	74.0	159.6
Operating,$MM/Yr	5.0	5.5
Cost of Service,$/Bbl of SCO	1.2	2.1
SATELLITE PIPELINE (EACH)		
Capacity		
ATP Distillates,BPCD	15,107	
Bitumen,BPCD		15,000
Capital,$MM	7.5	13.8
Operating,$MM/Yr	0.3	0.3
Cost of Service,$/Bbl of SCO	0.2	0.4
CASE TOTAL (1)		
Capacity		
SCO,BPCD	31,200	31,200
ATP Distillates,BPCD	30,213	
Bitumen,BPCD		30,000
Capital,$MM	1100.8	1453.9
Sustaining Capital,$MM	113.4	318.6
Operating,$MM/Yr	175.8	191.8
Sulfur Revenue,$MM/Yr	7.0	10.6
Cost of Service,$/Bbl of SCO	28.2	33.4

Notes:
1. Includes two Satellites

06-Jul-89 :R.PADAMSEY

4.0 REGIONAL SECONDARY UPGRADER

4.1 Design Basis

The secondary upgrader module was designed as a stand-alone single train facility containing atmospheric distillation, naphtha-distillate hydrotreater, heavy gas oil hydrotreater, hydrogen plant and other units required to produce a fully upgraded SCO. The secondary upgrader has an overall service factor of 90%.

Total feed to the secondary upgrader consists of 30,214 BPCD of ATP distillates. SCO is produced at rate of 31,200 BPCD. A block flow diagram with material balance and product qualities is presented in Figure 4.1.

Power and natural gas requirements are purchased offsite with no internal power generation. The utility balance is presented in Table 4.1.

4.2 Investment Estimate

The capital and operating cost estimates was generated in 3Q 1987 Canadian dollars.

The scope of the capital cost estimate included the following:

- Equipment & Bulks
- Direct Labour ($19.5/hr) and Subcontract Labour ($42.9/hr)
- Land and Site Work
- Freight (3% of equipment and bulks)
- Spares (5% of equipment)
- Catalyst and Chemicals
- Import Duties (2.5% of equipment)
- Indirect Field Costs (180% of direct labour cost)
- Engineering and Office Costs (15% of total constructed cost)
- Bus Rental/Travel Premium
- Insurance (1% of total constructed cost).
- Owners and Start-up Budget (10% of total constructed cost)
- Contingency (25%)

The scope of the operating cost estimates included the following:

Variable Costs:

- Energy Imports ($2.20/MMBTU natural gas, $0.05/kW electricity)
- Catalyst and Chemicals

Semi-Variable Costs:

- Operating Labour
- Maintenance Labour (2% of total constructed cost)
- Maintenance Material (1.5% of total constructed cost)
- Operating Supplies
- Sales, General and Administration
- Office Costs and Miscellaneous
- Insurance (0.25% of total installed plant cost)
- Local Taxes (0.5% of total installed plant cost)

- Bus Rental/Travel Premium for Maintenance Labour
- Interest on Working Capital (10%)

Working capital charges were based on inventory in tanks and process fill requirements. Costs were based on the following (approximate current market rates, June, 1987, as opposed to the calculated values presented in this report):

ATP Distillates	$20.00/BBL
SCO	$25.00/BBL

The detailed capital and operating cost estimates are presented in Table 4.2 and Table 4.3 respectively.

4.3 Economic Analysis

Economic analysis of the secondary upgrader was based on the determination of the supply cost, defined as the price (revenue) per barrel of SCO required to cover all capital and operating costs over the life of the secondary upgrader. The economic assumptions made are as follows:

(1) Discount rate of return 10%.

(2) No inflation, taxes, royalties, or depreciation.

(3) A sulphur credit applied based on $130.00/LT.

(4) A 3 1/2 year construction period inclusive of the first year's operation.

(5) A 25 year operating plant life.

(6) A capital investment and production schedule given by:

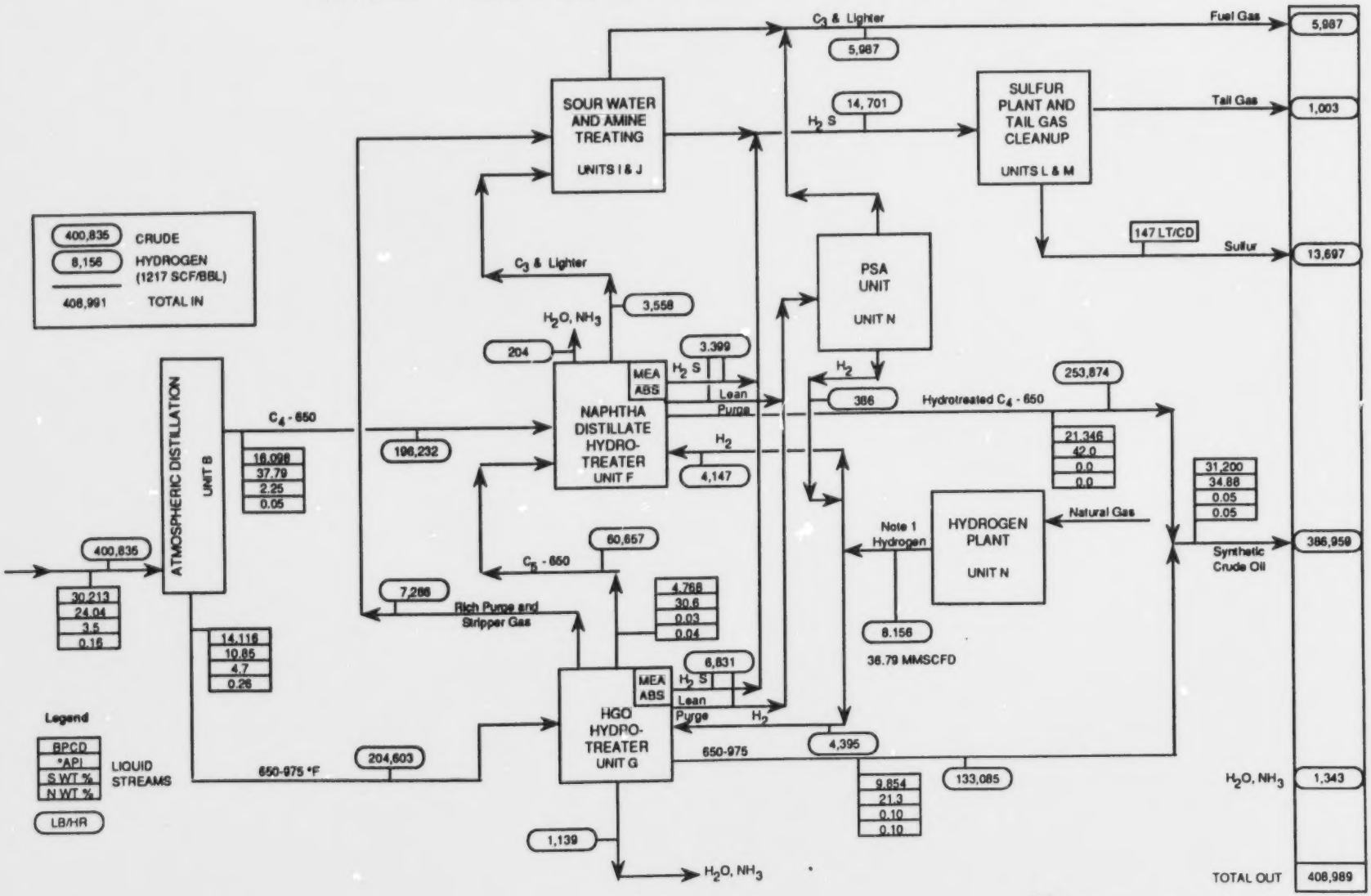
Year	Capital (%)	Production (%)
-3	20	
-2	35	
-1	30	
1	15	50
2		75
3-25		100

(7) An operating schedule based on the sum of the semi-variable costs and production related variable costs.

The secondary upgrader supply cost per barrel of SCO are as follows:

Capital	$	5.18
Operating		4.68
Sulfur Revenue		(0.61)
Total		9.25

FIGURE 4.1: REGIONAL SECONDARY UPGRADER - BLOCK FLOW DIAGRAM



R. Padamsey: June 15, 1989

Notes:
1. Hydrogen shown is pure Hydrogen

TABLE 4.1

REGIONAL SECONDARY UPGRADER - UTILITY BALANCE

UNIT	STEAM 15#	STEAM 40#	STEAM 125#	STEAM 600#	POWER MW	BFW USGPM	COND. USGPM	F/GAS FOEBCD
ATMOSPHERIC UNIT		2.1	4.1		0.9		(4.1)	391.2
N-D HYDROTREATER		(44.1)	(32.4)	44.1	1.2	65.1		104.0
HGO HYDROTREATER		(36.0)	(22.7)	59.0	3.9	10.0		95.7
SULPHUR & AMINE UNIT	(4.1)	60.8	(19.9)	(23.3)	0.3	135.7	(159.4)	85.9
HYDROGEN PLANT								(507.0)
SOUR WATER STRIPPER				(94.9)	1.1	389.0		2,589.0
MISC. UTILITIES		9.6			0.0		(19.1)	
STEAM PLANT		14.4	48.3	13.7	1.9		(58.9)	
IMPORT/(EXPORT)	4.1	(6.7)	22.6	1.4		(599.8) 315.0	241.6	
	0.0	0.0	0.0	0.0	9.3	315.0	(0.0)	2,758.8

R.PADAMSEY:04-Jul-89

TABLE 4.2

REGIONAL SECONDARY UPGRADER
CAPITAL COST ESTIMATE - 1000's 1987 3Q CAN $

Equipment Cost		99,187
Bulks		50,876
Labor		
Direct	22,437	
Subcontract	34,345	
Subtotal		56,782
Other Costs		
Land Cost and Site Work	10,000	
Freight	4,502	
Spares	4,959	
Catalyst & Chemicals	10,754	
Imp.Duties	2,480	
Subtotal		32,695
Direct Field Costs		239,540
Indirect Field Costs		40,386
Total Constructed Cost		279,926
Engineering & Office Costs		41,989
Bussing/Travel Premium		7,024
Insurance		2,799
Owners Budget		27,993
Start-up Budget		13,996
Contingency		93,432
TOTAL INSTALLED PLANT COST		467,159

04-Jul-89 :R.PADAMSEY

5.0 SATELLITE MINE/ATP PRODUCTION FACILITIES

5.1 Design Basis

5.1.1 Mine

The site terrain is similar to that of the Syncrude site and/or the proposed OSLO and Alsands sites. The land features are generally flat, with wet muskeg deposits overlaying the granular overburden. The nominal waste to ore ratio is taken at .75, with average thickness of the sections being: overburden 25m, centre reject 5m and ore 40m. The average ore grade (wt % content of bitumen) is 10.7%, including dilution.

The mining method is open pit shovel-truck. Mine development is by conventional construction equipment and contracts. Hydraulic shovels are specified for mining the waste and ore. Waste and ore transport is by medium size off highway mining trucks, hauling directly to the disposal areas or the processor feeders.

The mine operates year around to supply an average quantity of 1150 tonnes per calendar hour to the ATP plant. Annual quantities are 4.9 million m^3 of ore and 3.8 million m^3 of waste (10 million and 7.5 million tpy respectively).

5.1.2 Tailings Disposal

The dry tailings are conveyed from the Processor and stacked in a nominal 24 hour storage. From there the tailings are rehandled by loader and truck and transfered initially to an adjacent disposal area for approximately six years. After the first six years of the mine operation, the mine can accept tailings directly from the ATP plant for permanent disposal.

The truck fleet is designed to transport 8.6 million tonnes of dry tails per year, at an average rate of 1434 tonnes per hour while operating.

5.1.3 ATP Plant

Each of the ATP plants consists of two ATP Processors of capacity 710 tph each, and associated plant process equipment to facilitate oil sand feed, oil product distillate recovery, flue gas treatment, tailings discharge and products storage and handling. Each ATP plant produces 15,107 BPCD of ATP distillates. The plant process configuration is shown in the Figure 5.1. The main design basis data are as follows:

- The plant service factor is 0.8. Annual production operating hours are 7008.

- Oil Sand Plant Feed Composition (wt. basis)
  - Solids - 84%
  - Bitumen - 10.7%
  - Water - 5.3%
  - Fines - average of 18 wt.% of solids.

- Bitumen Recovery as ATP distillates(C_4+ Distillate) - 74 wt %

- Plant Tankage - adequate for process fill plus inventory to ensure the 15,107 BPCD to the secondary upgrader from each satellite mine/ATP production facility.

- Utilities - Electric Power and Natural Gas purchased commercially.

5.2 Investment Estimate

5.2.1 & 5.2.2 Mine & Tailings

The capital and operating cost estimates for the mine and tailings operations were generated as a separate, stand-alone activity, such as might be conducted by a contractor.

The scale of the material handling activity would be well within the capability of several local contractors.

The cost summaries shown in Table 5.3 do not include:

- Contingency - as the cash operating cost is regarded as generous.
- Taxes or royalties.
- Financing.
- Inflation or depreciation.
- Capital recovery.
- Long term reclamation.
- Site access.
- Sub-ore depressurization.

The costs do include the following:

- Erection of the shovels and shops.
- Initial spare parts (running inventory).
- Purchase costs for natural gas (heating), power and fuel.
- All off-site component maintenance.
- Annual shop maintenance and capital replacement (cranes, hoists, etc.).
- All field labor up to the mine manager level.
- All equipment replacement costs except for the last three years, i.e. the equipment has all reached or passed it's replacement life by the suspension of mining.

5.2.3 ATP Plant

The detailed capital cost estimates for an ATP plant which supplies 15,107 BPCD of ATP distillates is presented in Table 5.1. The estimates include cost for site development, plant foundations, equipment supplies and installation.

The plant operating costs are shown in Table 5.2, and include variable costs for items directly affected by production, such as power and fuel consumption, and semi-variables are items such as staff, maintenance, and services.

The estimates exclude costs for taxes, permits, royalties, financing, inflation and depreciation.

5.3 Economic Analysis

The economic analysis of the satellite mine/ATP production facilities was based on the determination of the supply cost, defined as the price (revenue) per barrel of SCO required to cover all capital and operating costs over the life of the satellite facility. The economic assumptions used are given as follows:

(1) Discount rate of return 10%.

(2) No inflation, taxes, royalties, or depreciation.

(3) A 3 1/2 year construction period inclusive of the first year's operation.

(4) A 25 year operating plant life.

(5) A capital cost (initial and sustaining), operating costs and production schedule given in Table 5.3

The satellite mine/ATP production facility supply cost per barrel of SCO are as follows:

Capital	$ 6.23
Operating	11.29
Total	17.52

FIGURE 5.1: ATP PLANT BLOCK FLOW DIAGRAM

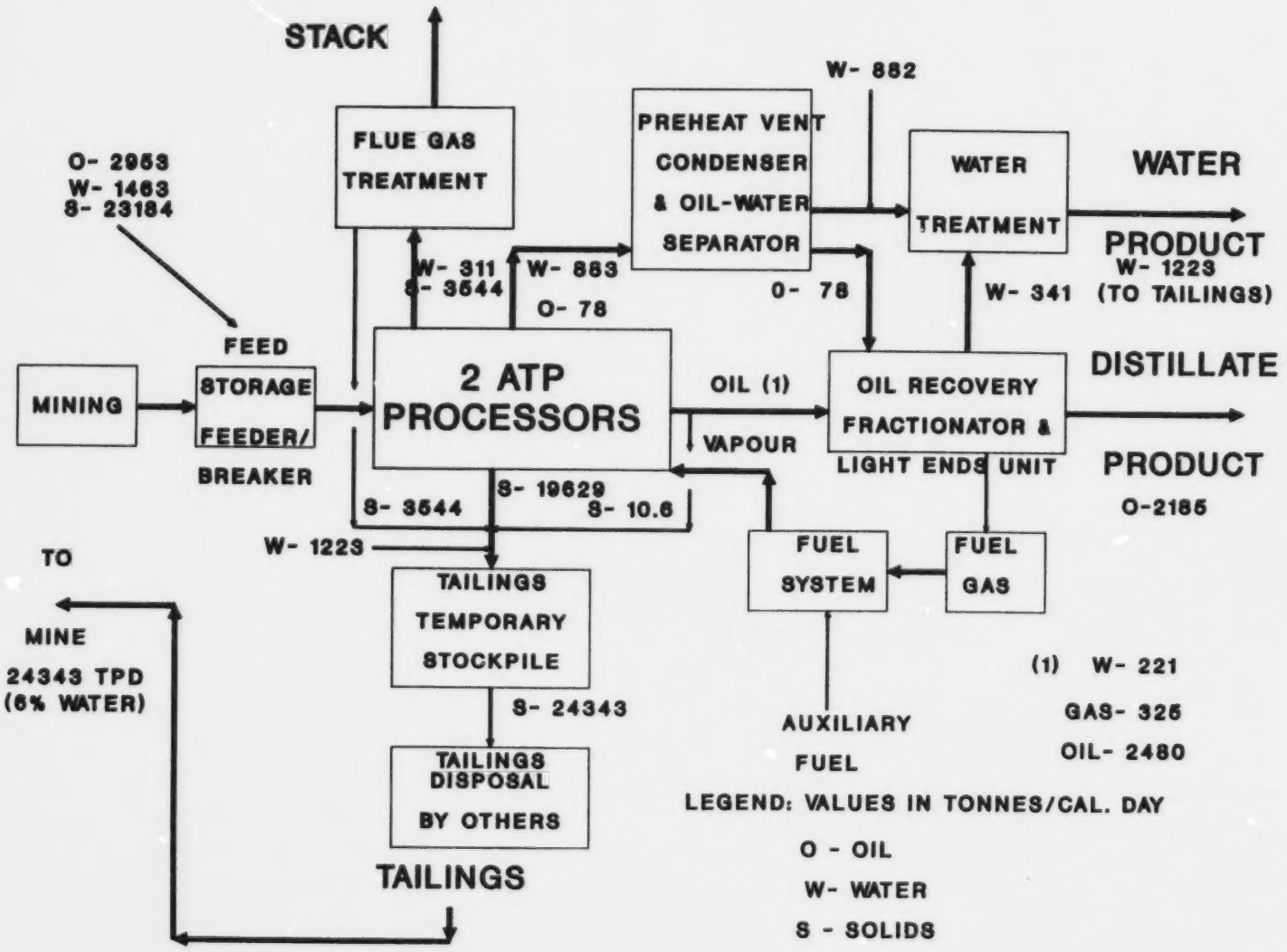


TABLE 5.1
ATP PLANT - 15,107 BPCD ATP DISTILLATES
CAPITAL COST ESTIMATES - 1000's 1987 3Q CAN $

Equipment Cost	47,993
Bulks	19,583
Labour	23,549
Reagents & Chemicals	1,275
Spares	2,743
Freight	4,909
Equipment Design Allowance	2,743
Total Direct Field Costs	104,463
Indirect Field Costs	48,653
Total Constructed Costs	153,116
Home Office Costs	23,877
General	1,446
Training & Manpower Development	7,020
Warehousing & Small equipment	3,546
Contingency (25% of above)	47,251
Total Installed ATP Plant Cost	236,256

TABLE 5.2

ATP PLANT - 15,107 BPCD ATP DISTILLATES
OPERATING COSTS ESTIMATE 1000'S 1987 3Q CAN $/YEAR

Variable Costs	
Natural Gas	331
Electric Power	3,431
Reagents & Chemicals	2,292
Subtotal	6,054
Semi-variable Costs	
Operating Labor	3,787
Maintenance Labour	4,030
Maintenance Supplies	5,800
Operating Supplies	777
Technical & Admin. Labor	1,913
General Costs	2,000
Contracting Costs	3,816
Camp Costs	403
Interest on Working Capital	416
Subtotal	22,942
Total Annual Operating Costs	28,996

6.0 PIPELINES

6.1 Investment Estimate

The Capital and Operating costs for the trunk pipeline was assumed to be similar to that of ACR's Case 2 Trunk pipeline since the services of these pipelines are very similar.

The capital and operating cost for the satellite pipeline was developed inhouse by AOSTRA.

The capital and operating cost are as follows:

	Trunk	Satellite
Capital, $MM	74.0	7.5
Operating, $MM/Yr	5.0	0.25

6.2 Economic Analysis

Economic Analysis of the pipelines was based on the determination of the supply cost, defined as the price (revenue) per barrel of SC0 required to cover all capital and operating costs over the life of the pipelines. The economic assumptions made are as follows:

(1) Discount rate of return 10%.

(2) No inflation, taxes, royalties, or depreciation.

(3) A 2 1/2 year construction period inclusive of the first year's operation.

(4) A 25 year operating plant life.

(5) A capital investment, operating cost and production schedule given by:

Year	Capital (%)	Production (%)	(%) Operating
-3			
-2	25		
-1	60		
1	15	50	60
2		75	80
3-25		100	100

The pipeline supply cost per barrel of SCO are as follows:

	Trunk	Satellite
Capital	$ 0.78	$ 0.16
Operating	0.44	0.05
Total	1.22	0.21

APPENDIX A

ADVANCEMENTS IN DEVELOPMENT OF THE AOSTRA TACIUK PROCESSOR

ADVANCEMENTS IN DEVELOPMENT OF THE AOSTRA TACIUK PROCESSOR

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MARCH 16, 1988

CONTENTS

ABSTRACT

INTRODUCTION

TACIUK PROCESSOR

TACIUK PROCESS SYSTEM DESCRIPTION

FEED MATERIALS PROCESSED IN PILOT PLANT

PILOT PLANT RUN SUMMARY

TACIUK PROCESSOR PRODUCT QUALITY

COMPARISON OF CRACKED OIL YIELDS

ECONOMIC COMPARISONS

UNIT CAPITAL AND OPERATING COSTS

PROCESS ADVANTAGES

OIL SHALE PERFORMANCE TEST RUNS

HEAVY OIL WASTES PERFORMANCE TEST RUNS

DEVELOPMENT STEPS TO COMMERCIALIZATION

SUMMARY STATUS OF TACIUK PROCESSOR TECHNOLOGY

PILOT VISITATION

AVAILABILITY OF DATA

ADVANCEMENTS IN DEVELOPMENT OF THE TACIUK PROCESSOR

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ABSTRACT

The Taciuk Processor is a single, horizontal, rotating vessel which processes oil sands to extract the bitumen and produce a partially upgraded oil. The quality of the product oil is similar to Fluid Coker distillate. The main feature of the Taciuk Processor is its ability to recover more products from a wide range of oil sands ore when compared to existing commercial technologies. The spent sand produced is clean and environmentally acceptable for disposal as land fill or returned to the mine pit.

Extensive testing has demonstrated the ability of the Processor to process oil shales and process hydrocarbon contaminated solid wastes to produce clean hydrocarbon-free solids suitable for landfill.

The associated external systems required to collect the product streams are known technologies.

Over 12,000 tons of oil sands, 1,600 tons of oil shales and 300 tons of hydrocarbon waste material has been processed by the 5 Ton/Hour Taciuk Processor Pilot in Calgary. The more than 300 test runs performed to date have provided proven process technology and justified confidence in scale-up and mechanical integrity.

The economic comparisons to existing commercial hot water processes favour the Taciuk Process. The Taciuk Process System is ready to be demonstrated on a specific oil sands lease. A key feature of the Taciuk Processor is its ability to add to plant capacity by the addition of extra processor trains of progressively larger sizes. Hence a demonstration plant can readily expand to commercial production.

INTRODUCTION

UMATAC Industrial Processes, a Division of UMA Engineering Ltd., in cooperation with the Alberta Oil Sands Technology and Research Authority (AOSTRA), has developed a direct thermal process which simultaneously cracks hydrocarbons present in oil sands feed, recovers the liquid oil fractions as a hot vapor, recovers the gas fractions and burns coke deposited on the host sand to provide the major heat requirements of the process. Initial development started in 1975 with batch scale testing. In 1977, development agreements were signed with the Alberta Oil Sands Technology and Research Authority whereby a pilot plant would be constructed and operated in Calgary. This plant was completed in early 1978, operated as a coker during 1978 using a reduced crude feedstock for initial testing simplicity, then operated during 1979 and 1980 on various grades of oil sands feed. Process and operating data provided encouraging results for plant performance and proved the basic concepts.

During the period 1981 - 1982, further test work on oil sands varying in bitumen content from 6% to 14% was successfully completed.

Oil samples from these runs were analyzed in detail to illustrate the oil consistency over a range of oil sands feeds, and to provide an assessment of hydrotreating requirements.

To date, about 12,000 Tons of oil sands have been successfully processed at the 5 ton per hour Taciuk Processor pilot plant in Calgary.

During the period 1983-1984, efforts were concentrated on scale-up definition, demonstration and commercial processor design, and on

capital and operating cost comparisons relative to processes now in commercial use.

The capital and operating cost estimates for a 1,000 ton/hour oil sands plant (about 10,000 BPCD oil products) using the Taciuk Processor was completed in 1986. The facility was to be located on Lease 87, north of Fort McMurray and consisted of a mine, Taciuk Processor, oil recovery and all infrastructures and utilities required to satisfy process needs and meet existing environmental constraints.

The stabilization of world crude oil prices will make it more attractive for industry to justify new development of oil sands mining leases.

The Taciuk Processor can also efficiently process oil shales and hydrocarbon waste materials. During 1987, 1400 tonnes of Australian oil shales were successfully processed in the pilot plant. We are currently testing the clean-up of hydrocarbon waste materials from sludge pits, refinery sites and other oil contaminated sites.

TACIUK PROCESSOR

The Taciuk Processor consists of a single, horizontal, rotating vessel containing individual compartments that perform the processing steps required to recover and separate various product streams. (Figure 1).

In the oil sands-treatment mode, as-mined oil sands feed is introduced into the preheating section of the Processor where connate water is evaporated as steam, frozen material is ablated, oversize material is removed and solids are heated by heat exchange with the hot, outgoing tailings sand. The preheated sands are then transported into the reaction zone where they are mixed with hot sand from the combustion zone. The resulting temperature is adequate to thermally crack the hydrocarbons, yielding a vapor stream containing the cracking reaction gases and liquids (in vapor form), and leaving a coke-residue coating

on the sand. The hydrocarbon vapor stream leaving the Processor is passed through cyclones to remove fine solids, then processed through a fractionating tower where liquid fractions may be separated for further processing. Fractionator off-gases are further cooled to condense light ends and water, then passed to a central gas processing plant to recover additional light ends. A heavy bottoms oil cut from the fractionating tower can be recycled back to the Processor reaction chamber or used as supplemental process fuel. The product oils can be pumped to downstream, or remotely located, hydrotreating facilities or sold as fuel.

The coke-coated sand leaving the reaction zone discharges into the combustion zone. In this zone, preheated air is injected to burn most of the coke to provide heat for the Processor. Auxiliary burners are available to provide heat for startup, trim control and emergency conditions. The hot sand from the combustion zone passes through a recycling arrangement that ensures an adequate supply of hot sand to the reaction zone, while allowing net sand to move into the outer heat exchange compartment. As the net sand flows through the heat exchange zone, it is cooled by giving up heat to the incoming oil sands feed. The partially cooled tailings sand is removed from the Processor, further cooled and wetted by water addition, then transported by conveyors or trucks to a tailings area or mined out area.

Combustion gases leaving the Processor flow through cyclones to reduce the fine solids, then pass through scrubbers that remove most of the remaining fine solids and chemically remove most of the sulfur dioxide produced by the combustion of coke. The wet scrubber liquid can be used as a cooling medium for the tailings sand.

TACIUK PROCESS SYSTEM DESCRIPTION

The Taciuk Process System consists of several collection, treating and handling systems connected externally to the Processor unit. The major systems, flows and products are illustrated in Figure 2, and consist of the following:

1. Feed System comprising of hoppers for feeding oil sands.

2. Low Temperature Steam System which is used to collect all steam, light hydrocarbons and inert gases produced in the feed preheating zone. This effluent can be directly discharged or condensed and processed for oil recovery if light oils are present in this stream.

3. Hydrocarbon Vapor System which is used to collect all vapors produced in the reaction zone. These hot vapors are products of thermal cracking and exit at approximately 1000°F. This flow is processed through cyclones, fractionator, condensers, heat exchangers, gas compressors and separators to produce water, oil and gas by-products.

4. Flue Gas System which is used to collect all combustion gases and leakage gases from the Processor and its systems. These gases are cooled, treated for particulate removal, then treated for chemical removal of other impurities, such as sulfur dioxide, prior to release to the atmosphere.

5. Combustion Air and Auxiliary Burner Systems for coke and process fuel combustion are designed to suit the particular feed characteristics. Fuel derived from thermal cracking, in the form of coke and C_4 minus off-gases, is used for primary heat requirements and can be supplemented by combustion of a portion of the oil product in the auxiliary burners if this is required.

6. Solid Discharge Cooling and Handling Systems to provide final cooling, mixing with water to control dust during handling, and conveyors to carry the discharge to storage piles.

7. Other Product Storage and Handling Systems including storage tanks, emergency flare stack, nitrogen blanketing and other miscellaneous systems.

8. Heat Exchange Systems for oil vapor condensing, flue gas cooling, tailings cooling, combustion air preheat and for satellite steam generation can be incorporated on the various flow streams depending on individual plant requirements.

FEED MATERIALS PROCESSED IN PILOT PLANT

Over 12,000 tons of oil sands, 1,600 tons of oil shales, and 300 tons of hydrocarbon waste material, have been processed by the 5 ton/hour Taciuk Processor pilot plant in Calgary. Figure 3 illustrates the range of Athabasca oil sands piloted. The test runs were successfully conducted and the results consistently reflected the positive performance of the Processor in its extraction and partial upgrading of the bitumen when processing oil sands. There is a significant amount of test run data available to support the performance of the Taciuk Processor.

PILOT PLANT RUN SUMMARY

The Taciuk Processor utilizes proven mechanical design features of rotary kilns and the unique/proprietary features of flow, heat exchange, pressure seals and hydrocarbon separation. These features which have been perfected in the more than 300 test runs for mechanical

performance, sand flow, product heating, separation, heat exchange and partial upgrading of feed such as oil sands, oil shales and heavy oil waste sludges are illustrated in Figure 4. The runs ranged from short runs of several hours to extended runs of up to 6 days. The pilot Processor has experienced more than 500 heat-up and cool-down cycles. The low process pressure feature and simplicity of mechanical design indicates a rugged and simple piece of equipment to operate when compared to the sophisticated equipment required in existing commercial extraction/upgrading processes.

TACIUK PROCESSOR PRODUCT QUALITY

The product produced by the Taciuk Processor from oil sands feed is very similar to coker distillate. Figures 5, 6 and 7 illustrate the product quality as well as the negligible variation in the product slate over a wide range of grades of oil sands.

COMPARISON OF PRODUCT YIELDS

One of the key features of the Taciuk Processor is its ability to process a wide range of grades of feed oil sands and still recover a significantly high ratio of the bitumen in the feed. Figures 8 and 9 illustrate that the Taciuk Processor can:

1. recover product oil from bitumen at a relatively higher level of efficiency than the corresponding hot water extraction process in combination with coking processes.

2. recover product oil from bitumen in low grade oil sands feed almost as efficiently as from high grade ore.

The above features result in significant savings in processing costs because of its workability over a wide range of ore quality.

ECONOMIC COMPARISON

It is important to compare the Taciuk Process System against the currently used hot water extraction process in combination with coking processes from the point of view of equipment configuration, invested capital and unit operating costs. Figure 10 illustrates the simplicity of the Taciuk Process System. Figures 11 and 12 provide a relative economic comparison of the Taciuk Process System with the hot water extraction plus Flexicoking for small and large size plants. This comparison was based upon plant capital and operating cost estimates of [illegible] or minus 25%, and hence should be considered from a relativity [illegible] point instead of absolute values. Nonetheless, the economic advantage of the Taciuk Process System seems evident.

UNIT CAPITAL AND OPERATING COSTS

Based upon several site-specific designs and cost estimates, Figures 13 and 14 illustrate the unit capital cost of installed capacity and unit operating costs. (All values are in Canadian Dollars.)

SUMMARY OF ADVANTAGES OF THE TACIUK PROCESS SYSTEM

Figures 15A and 15B summarize the major process advantages of the Taciuk Process System, i.e., consistent oil recovery over a range of feed grades, production of damp oil-free tailings (no tailings ponds), lends itself to staged project capacity addition, is a simplified process plant and has significant economic advantages in capital and operating costs.

OIL SHALE PERFORMANCE TEST RUNS

The Taciuk Processor lends itself readily to the processing of oil shales. Shale feed preparation consists essentially of crushing to less than an inch diameter size and some predrying, depending on the quality of the oil shale. Approximately 1,600 tons of Australian oil shales have been successfully processed at the 5 ton/hour Taciuk Processor pilot plant in Calgary. The test results have shown consistently high oil recoveries and minor deterioration of the host shale. The purpose of the tests was to confirm the use of the Taciuk Processor for development of the Stuart oil shale deposits in Queensland, Australia. The Taciuk Processor is considered superior to other oil shale processing schemes from the U.S.A., Europe and Japan.

Preliminary designs and cost estimates have been prepared for 2,000 tonnes/day, 6,000 tonnes/day and 10,000 tonnes/day demonstration plants.

HYDROCARBON WASTE TREATMENT PERFORMANCE TEST RUNS

The area of clean-up of contaminated land fill sites in Canada and the United States is one of major proportions and of immediate concern. There is a pressing need to find a process that will separate the hydrocarbons from the host sand without incineration.

The Taciuk Processor essentially meets all these requirements, i.e. it separates the hydrocarbon components from the host sand when treating hydrocarbon bearing waste materials.

Together with Environment Canada, ERCB, Alberta Environment, Saskatchewan Environment and industry participants, we are currently conducting an important study and pilot test runs to prove to potential industry users, that the Taciuk Processor can treat these wastes at a highly competitive cost and reclaim all the host sand. This will provide a significant/proven technology to clean up heavy oil production wastes, clean up contaminated/abandoned refinery sites and other identified sites considered to be of environmental concern.

Having conducted numerous batch tests, we are currently processing about 250 Tons of hydrocarbon waste materials from the Lloydminster area in 5 runs at the Taciuk Processor Pilot in Calgary. We have seen preliminary results which indicate the Taciuk Processor is a usable/viable technology.

DEVELOPMENT STAGES LEADING TO COMMERCIALIZATION

The Taciuk Process System lends itself to staged capacity addition. Assuming a truck and shovel small mine operation, a Taciuk Process System producing 3,000 BPCD, 5,000 BPCD or 7,000 BPCD could be the capacity range of potential demonstration plants. These plant capacities can be accommodated by one Taciuk Processor. However an oil sands lease developer may want to consider starting at a particular size and then eventually adding additional trains of larger size Processors (see Figure 16).

A typical schedule for engineering, procurement, construction and operation of a demonstration plant is in the order of 4 years as shown in Figure 17.

SUMMARY STATUS OF TACIUK PROCESSOR TECHNOLOGY

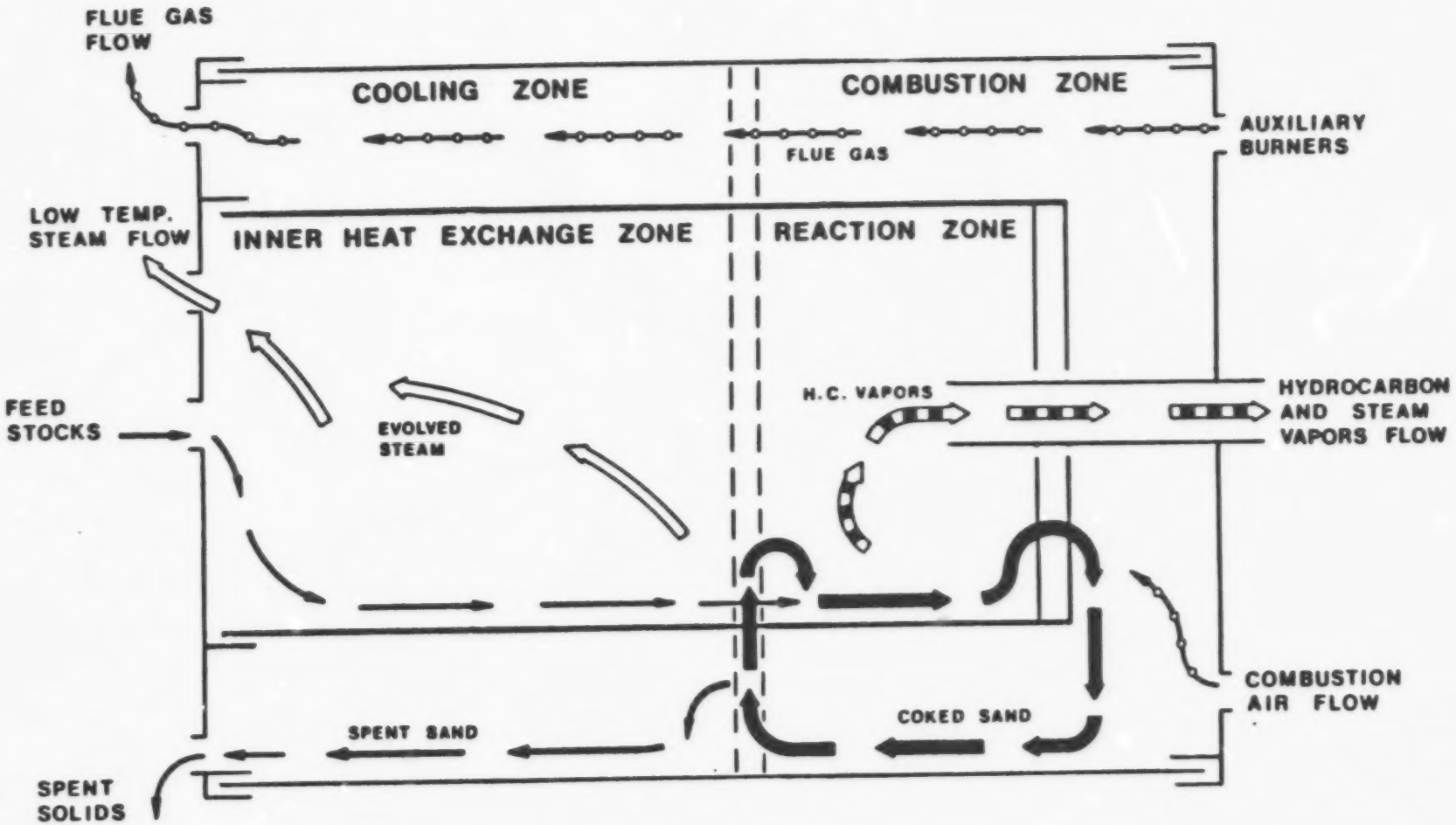
The Taciuk Processor Technology is sufficiently proven by numerous successful pilot runs indicating its process performance, operating reliability, and mechanical integrity. The next stage is to build and operate a demonstration size plant. Figure 18 summarizes the current stage of technology development. A suggested listing of the objectives of a demonstration plant for a specific oil sands lease is outlined in Figure 19.

PILOT PLANT VISITATION

The Taciuk Processor Pilot Plant is located in Calgary and can be visited upon request to either AOSTRA or UMATAC. It consists of various size batch testing equipment for pyrolysis and combustion tests and a 5 ton/hour Taciuk Processor with its ancilliary external systems.

AVAILABILITY OF DATA

Test run results, cost estimates, economic comparisons and sensitivity studies are available from AOSTRA.



TACIUK PROCESSOR

FIGURE 1

FEED MATERIALS PROCESSED IN THE PILOT PLANT

- 3000 TONS	11-12% SYNCRUDE OIL SANDS
- 2500 TONS	11-13% SUNCOR OIL SANDS
- 1200 TONS	9% SYNCRUDE OIL SANDS
- 300 TONS	14% SYNCRUDE/SUNCOR OIL SANDS
- 500 TONS	6-7% SUNCOR OIL SANDS
- 600 TONS	6-8% SYNCRUDE OIL SANDS
- 600 TONS	8-10% SUNCOR OIL SANDS
- 90 TONS	8% UTAH OIL SANDS
- 1000 TONS	7-9% SUNCOR OIL SANDS
- 2000 TONS	11-13% SUNCOR OIL SANDS
- 600 TONS	4-8% MALAGASY OIL SANDS
- 1000 BARRELS	GULF REDUCED CRUDE
- 150 BARRELS	LLOYDMINSTER CRUDE
- 1600 TONS	AUSTRALIAN OIL SHALES
- 500 TONS	HEAVY OIL SLUDGE PIT MATERIALS

FIGURE 3

PILOT PLANT RUN SUMMARY

	PHASE A 1978-1980	PHASE B 1981-1982	1983-1988	TOTAL
MECHANICAL PERFORMANCE	42	15	-	57
PLAIN SAND	32	16	30	78
REDUCED CRUDE	41	16	-	57
ATHABASCA OIL SANDS	63	36	10	109
EXTENDED OIL SANDS	-	9	4	13
UTAH OIL SANDS	-	3	-	3
AUSTRALIAN OIL SHALES	-	-	13	13
HEAVY OIL WASTE SLUDGES	-	-	5	5
TOTAL	178	95	62	335

NOTES:

1. RUN LENGTH:
   - NORMAL - 8 TO 14 HOURS (HOURLY COMPLETE ANALYSIS)
   - EXTENDED - 30 TO 150 HOURS (BI-HOURLY COMPLETE ANALYSIS)

2. REPRESENTS - APPROXIMATELY 500 HEAT-UP/COOLDOWN CYCLES

FIGURE 4

TACIUK PROCESSOR
LIQUID PRODUCT QUALITY
(10% BITUMEN IN FEED)

GRAVITY	23.6 API
SULFUR	2.6 WT%
NITROGEN	1120 MG/KG
CCR	0.70 WT%

FIGURE 5

COMPARISON OF CRACKED OIL YIELDS

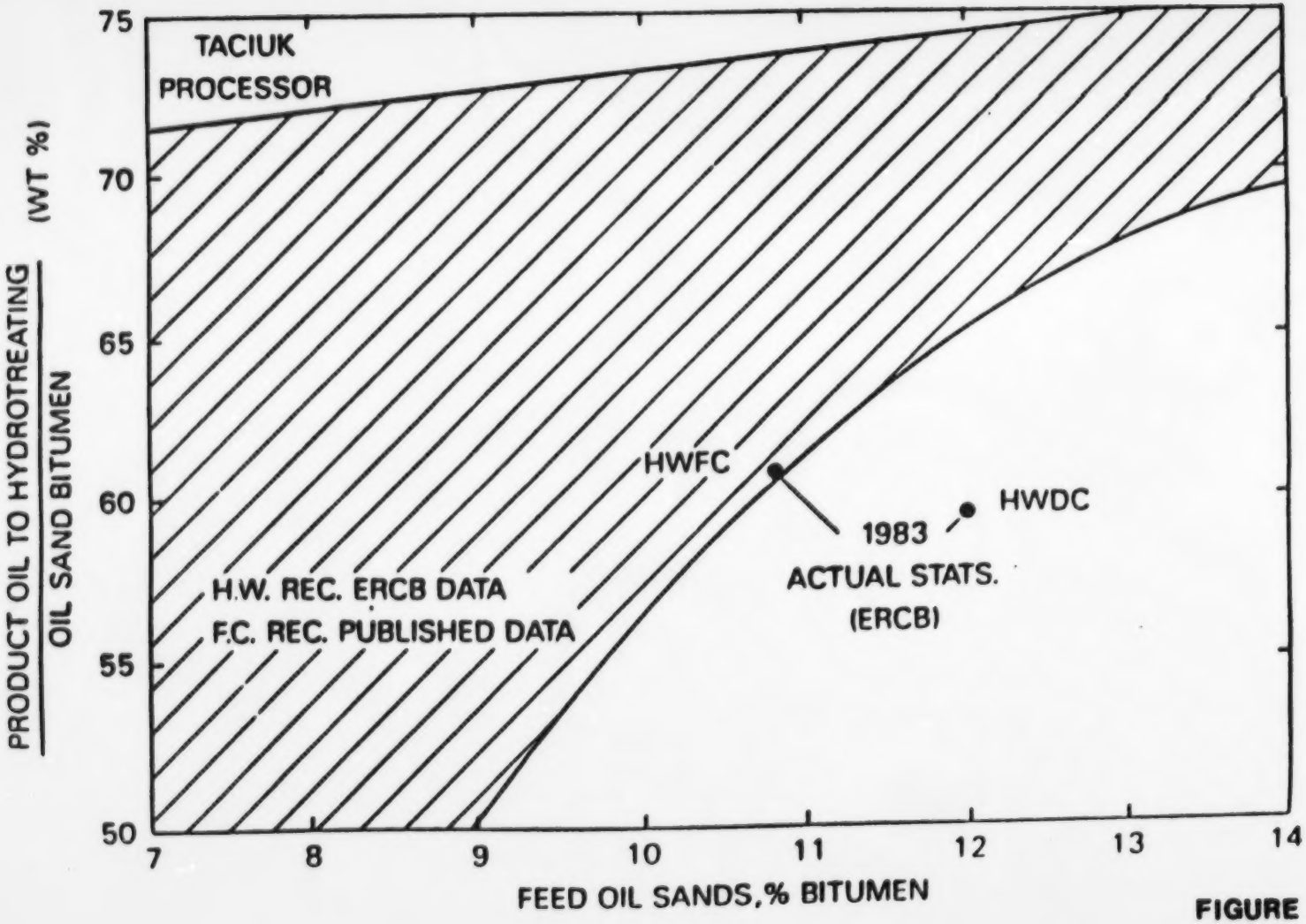


FIGURE 8

PRODUCT YIELD PATTERN VS FEED GRADE

PRODUCT	YIELDS, WT% OF BITUMEN		
	7.0% OIL SANDS (LOW)	11.6% OIL SANDS (AVERAGE)	14.0% OIL SANDS (HIGH)
C3 & LIGHTER GAS	8.7	8.7	8.7
C4 & HEAVIER LIQUID	71.5	73.9	75.2
GROSS COKE	19.8	17.4	16.1
TOTAL	100.0	100.0	100.0
OIL S.G. API	22.8	22.6	22.9

FIGURE 9

MINED OIL SAND PLANTS
MAJOR PROCESSING STEPS

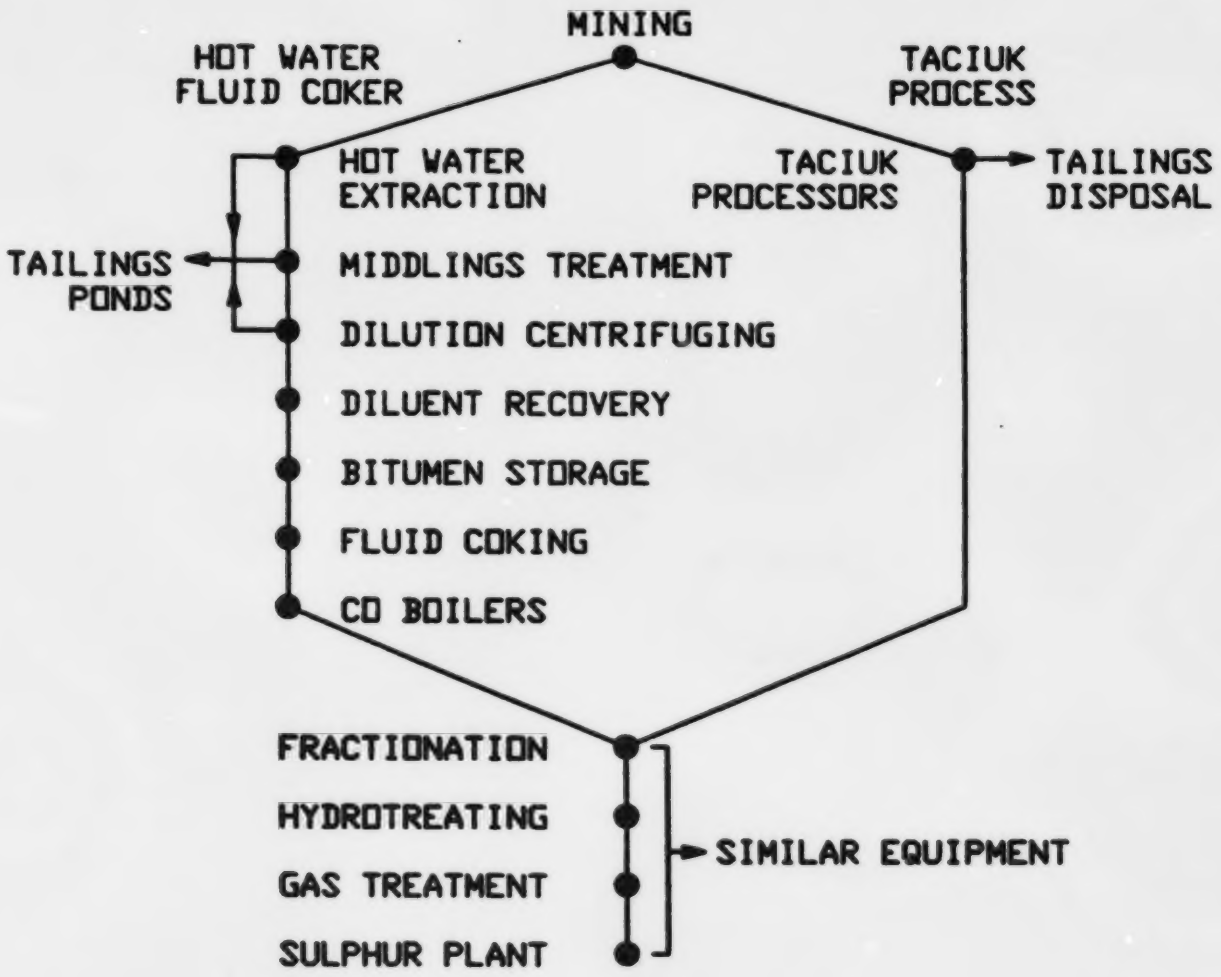


FIGURE 10

ECONOMIC COMPARISON - SMALL PLANT

ANNUAL FEED RATE - 22 MILLION TONS (11.6% BITUMEN)

	TACIUK	H.W.+FLEXICOKING
SYNTHETIC CRUDE PRODUCTION (BPCD)	33,689	30,025
CAPITAL COST ($MM)	1,122	1,246
CAPITAL COST/DAILY BARREL ($)	33,326	41,475
OPERATING COST ($/BARREL)	13.75	14.00
DCF ROR (%) *	32.5	24.2

* EXCLUDING TAXES ON INCOME AND CROWN ROYALTIES

FIGURE 11

FIGURE 13

UNIT CAPITAL COSTS

11.6% GRADE OIL SANDS

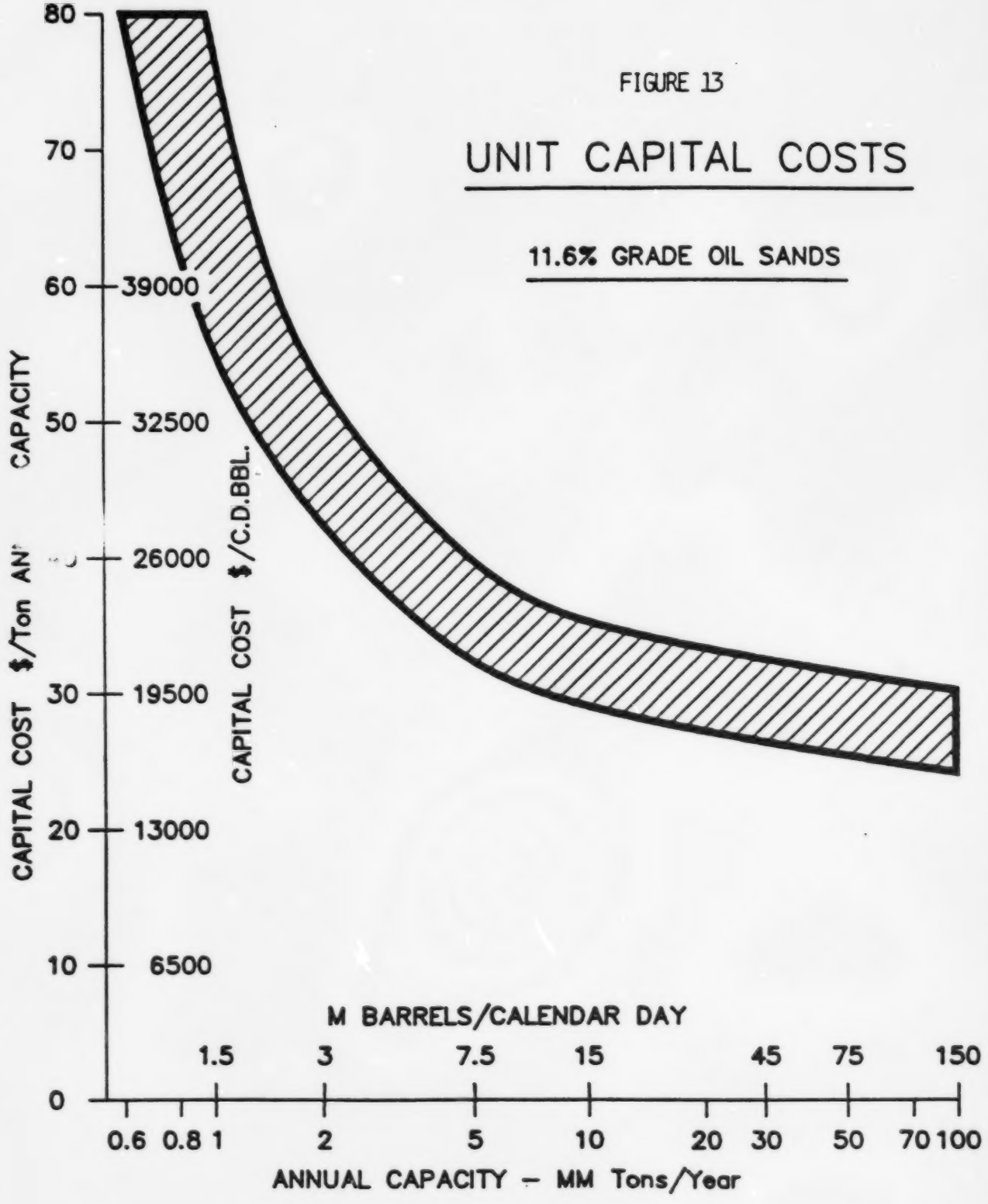
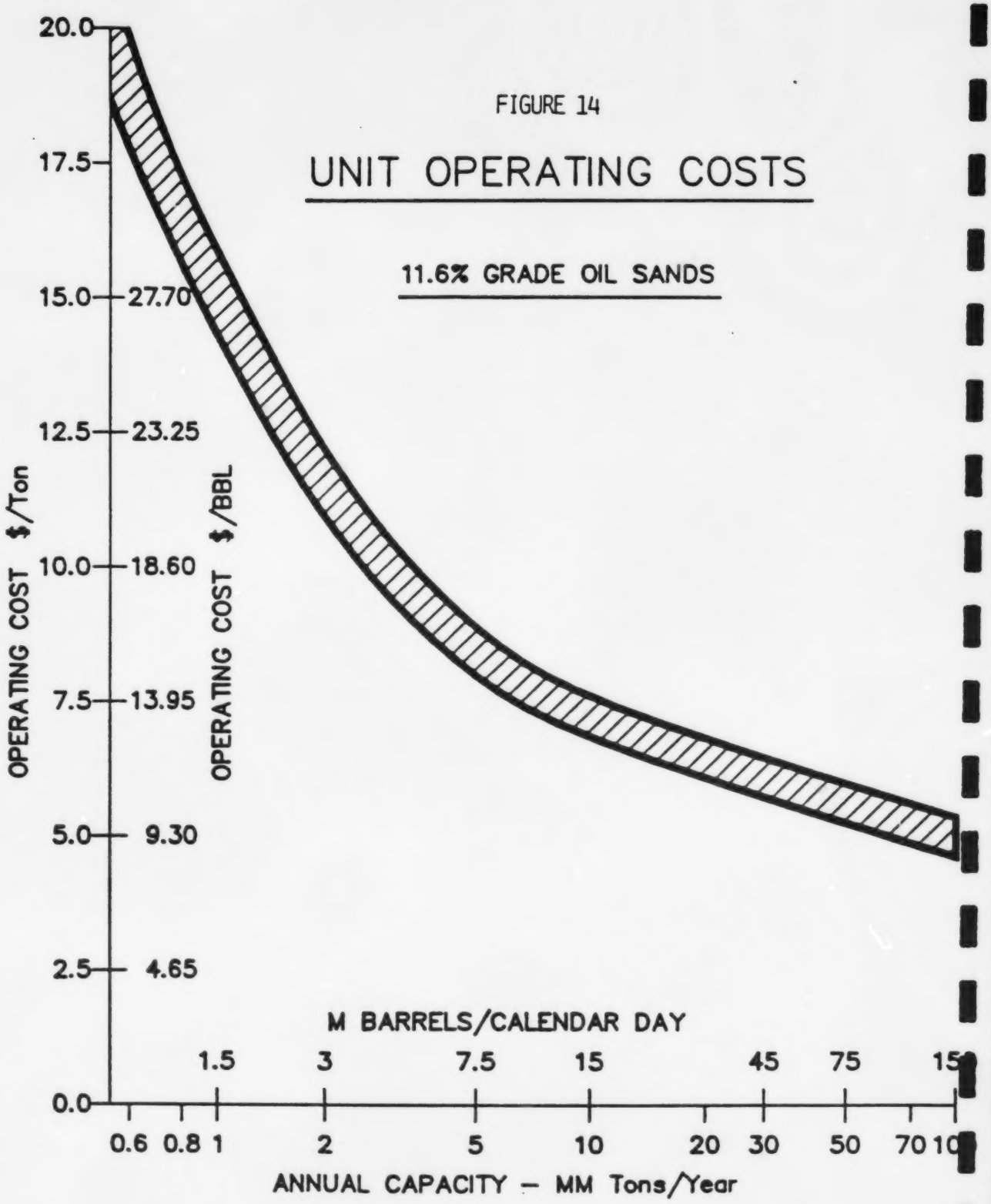


FIGURE 14

UNIT OPERATING COSTS

11.6% GRADE OIL SANDS



PROCESS ADVANTAGES

1) CONSISTENT OIL YIELD OVER RANGE OF FEED GRADES
   - RELAXES MINING CONSTRAINTS
   - REDUCES ECONOMIC LOW CUT OFF GRADE
   - PROCESS LOW GRADE OR LOW/HIGH GRADE MIXTURES

2) PRODUCES DAMP, OIL FREE TAILINGS
   - NO TAILINGS PONDS REQUIRED
   - REDUCED WATER CONSUMPTION (STEAM CONSUMPTION)
   - NO SLUDGE DISPOSAL PROBLEM
   - EARLIER DISPOSAL IN MINED OUT AREA
   - NO LONG TERM ENVIRONMENTAL IMPLICATIONS

FIGURE 15-A

PROCESS ADVANTAGES (CONT'D)

3) STAGED PROJECT CONSTRUCTION
   - SINGLE UNIT OPERATION - INITIALLY
   - ADDITIONAL PARALLEL UNITS ADDED AS REQUIRED
   - SMALL OPERATIONS WITHOUT SECONDARY UPGRADING (PUMPABLE OIL PRODUCED DIRECTLY)

4) SIMPLIFIED PROCESS PLANT
   - BITUMEN HANDLING ELIMINATED
   - MINIMIZE INTERMEDIATE STORAGE

5) REDUCED COSTS
   - REDUCED CAPITAL COSTS/BARREL
   - REDUCED OPERATING COSTS/BARREL

FIGURE 15-B

DEVELOPMENT STEPS TO COMMERCIALIZATION

UNIT	CAPACITY	SCALE-UP RATIO	BPSD PRODUCT OIL
PILOT	5 T/HR	1/1	70
DEMONSTRATION	350 T/HR	70/1	5,000
COMMERCIAL	1000 T/HR	3/1	14,000

FIGURE 16

DEMONSTRATION PROJECT - SCHEDULE

	MONTHS
FINAL DESIGN, PROCUREMENT & CONSTRUCTION	20-22
STARTUP AND INITIAL OPERATION	4-6
TESTING PERIOD	20-24
TOTAL PERIOD	48

FIGURE 17

DEMONSTRATION PROJECT

CURRENT DEVELOPMENT STATUS - RESEARCH COMPLETED
- PILOT OPERATIONS COMPLETED
- SCALE-UP RELATIONSHIPS DEVELOPED
- ECONOMIC COMPARISONS COMPLETED
- INITIAL DESIGNS COMPLETED
- MECHANICAL DESIGN OPTIMIZED

NEXT PHASE - DEMONSTRATION OF THE PROCESSOR ON OIL SANDS AT A SCALE SUITABLE FOR CONFIRMATION OF SCALE-UP RELATIONSHIPS AND PERFORMANCE TO PROVIDE A FIRM BASIS FOR COMMERCIALIZATION.

FIGURE 18

DEMONSTRATION PROJECT - OBJECTIVES

1) CONFIRM PROCESSOR PERFORMANCE AT
   - 11.6% BITUMEN CONTENT FEED
   - 7% BITUMEN CONTENT FEED
   - 14% BITUMEN CONTENT FEED
   - AS-MINED FEED (VARIABLE BITUMEN AND FINES)

2) CONFIRM SYSTEM OPERABILITY AND RELIABILITY

3) CONFIRM PROCESSOR SCALEUP PARAMETERS

4) CONFIRM PROCESSOR MECHANICAL DESIGN

5) CONFIRM ENVIRONMENTAL ACCEPTABILITY OF EFFLUENTS

FIGURE 19